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Review

Water hyacinth a potential source for value addition: An overview

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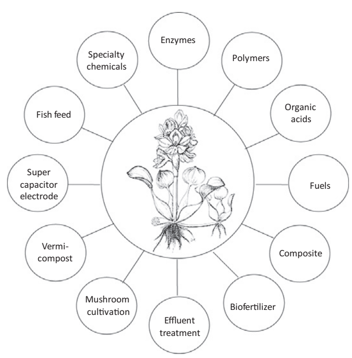
HIGHLIGHTS

- Overview on the production of value added products from water hyacinth.
- Recent trends in water hyacinth based biorefinery.
- Strategies for renewable fuels from water hyacinth.
- Several possibilities for the generation of wealth form this weed.
- Targeting multiple products would improve economic viability of process.

GRAPHICAL ABSTRACT



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ABSTRACT

Water hyacinth a fresh water aquatic plant is considered as a noxious weed in many parts of the world since it grows very fast and depletes nutrients and oxygen from water bodies adversely affecting the growth of both plants and animals. Hence conversion of this problematic weed to value added chemicals and fuels helps in the self-sustainability especially for developing countries. The present review discusses the various value added products and fuels which can be produced from water hyacinth, the recent research and developmental activities on the bioconversion of water hyacinth for the production of fuels and value added products as well as its possibilities and challenges in commercialization.

Contents

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1. Introduction

Water hyacinth (WH) is a free floating, perennial aquatic plant originated from Amazon river basin and have distributed throughout the world. It has exhibited extremely high growth rates and the coverage of waterways by WH has created several problems including destruction of eco systems, irrigation problems and also as a mosquito breeding place leading to increase in mosquito population (Sornvoraweat and Kongkiattikajorn, 2011). It is considered as the most productive plant on earth and now considered as a serious threat to biodiversity. These negative effects of WH lead to several research and developmental activities for the control of this notorious weed. Attempts to control this weed have high costs and labour requirements. Several biological, physical and chemical methods have been tried for the control and eradication of WH but none of these strategies proved to be a permanent solution for the control of this weed.

WH contains almost 20% of cellulose, 48% of hemicelluloses and 3.5% of lignin. The high hemicellulose and cellulose content of the WH can be explored for the production of various value added products and biofuels. Since the productivity is very high it could be utilized as a feed stock for the production of biofuels. WH has several advantages like it can grow on water without competing against arable land for growing grains and vegetables. Several reports are available for the conversion of WH to fuel ethanol and biogas (Okewale et al., 2016; Gunja et al., 2016; Das et al., 2016; Shah et al., 2015). The commonly used strains for the production of bioethanol from WH are *Saccharomyces cerevisiae*, *Pichia stipitis* and *Zymomonas mobilis*.

Discharge of industrial effluent to the environment creates several ecological and environmental issues. Aquatic plants are well known for water purification as well as extraction of heavy metals and nutrients. Compared to other aquatic plants WH is the most suitable aquatic weed for phytoremediation. The potential of WH for the removal of pollutants is a well-established environmental protection technique and it functions like "natures kidney" for removal of toxic compounds from water resources of earth. The biosorption potential of WH has been exploited for the removal of various heavy metals and pigments from various industrial effluents. Growing of WH in industrial effluents leads to decrease of total suspended solids (TSD), chemical oxygen demand (COD) as well as biological oxygen demand (BOD). The mechanism involved in biosorption is by extracellular accumulation/precipitation, cell surface sorption/precipitation and intracellular accumulation (Rai et al., 2002). Phytoremediation using WH is cost effective and eco-friendly process.

The present review addresses the recent developments and advances for the production of fuels and value added products from the nuisance weed WH.

2. Current conversion strategies

Lignocellulosic biomasses are composed of cellulose, hemicelluloses and lignin as the major component. Pretreatment is to be carried out to facilitate the separation of hemicellulose, cellulose and lignin, so that complex carbohydrate molecule containing cellulose and hemicellulose can be broken down by enzymatic saccharification to simple sugars. The main objective of the pretreatment is to make the cellulose accessible for enzymatic saccharification by removing hemicelluloses and lignin. Several pretreatment strategies are available for the fractionation, solubilisation, hydrolysis and separation of cellulose, hemicellulose and lignin. This includes physical methods, chemical methods and hybrid strategies.

Several reports are available on the pretreatment of WH like acid (Satyanagalakshmi et al., 2011), alkali (Pothiraj et al., 2014; Aswathi et al., 2013), biological (Sinegani et al., 2005), hot water (Saha et al., 2014), microwave-alkali (Zhang et al., 2016), ultrasound combined alkali (Soontornchaiboon et al., 2016), catalytic hydrothermal liquefaction (Singh et al., 2015), calcium peroxide (Cheng et al., 2015), surfactant free ionic liquid microemulsions (Xu et al., 2016), thermo-chemical conversion (Huang et al.,